FORAGE AND CATTLE RESPONSE TO SIERRA MEADOW RESTORATION

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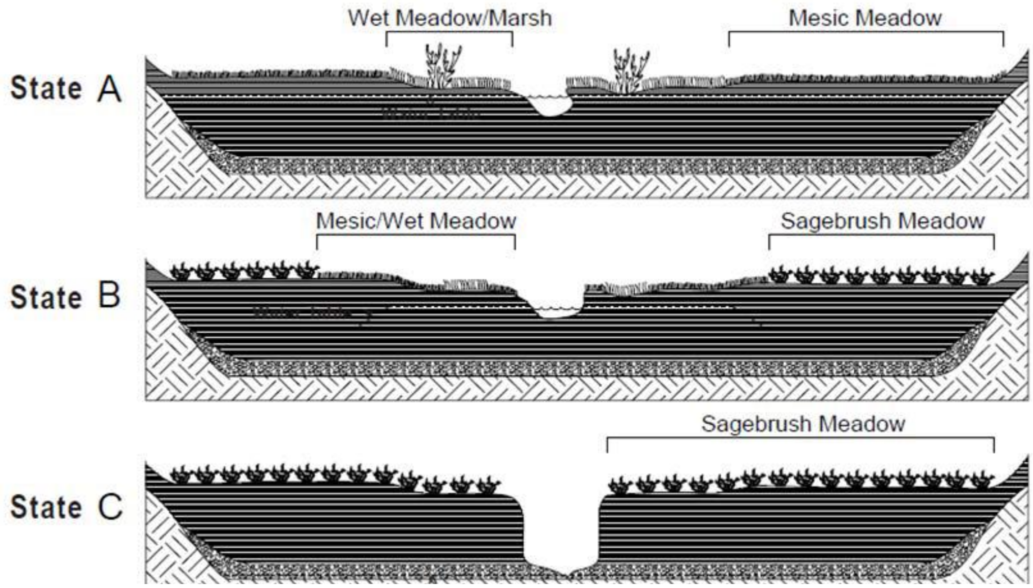
Background

There is significant interest in restoring Sierra meadows that have lost hydrologic function[1–3]. When the stream channel in a meadow downcuts, or erodes into its bed, water table levels in the meadow drop[4–8] and changes in plant communities occur (See Figure 1). Plant communities shift from sedges, rushes, grass and clover species, which require a shallow water table, to upland plants, and shrubs, which are better suited to dry soil conditions[9].



State A – *high hydrologic function, wet and mesic plant communities, high water table*

State B – *impaired/at risk hydrologic function, mesic/wet, mesic, and some dry communities, dropping water table, eroding stream*

State C – *degraded hydrologic function, downcut, dry plant communities*

Figure 1. Illustration of the changes in stream channel depth, depth to water table, soil moisture, and vegetation types (plant community) which occur when a meadow stream channel downcuts and meadow hydrologic function is diminished from State A to State C. From BLM/USFS/NRCS Tech Rept. 1737-15 1998[10].

Purpose

Our purpose was to evaluate how meadow restoration affects cattle production. We quantified changes in forage quality, forage production and cattle production associated with the return of wet or moist meadow vegetation, when downcut channels are restored.

Approach

We used values from the literature[9] and work from UC Davis range scientists, to estimate how restoration efforts that raise the water table in a meadow alter cattle production. Figure 2 illustrates the steps in our approach. When the water table is raised (*meadow hydrology*), predictable changes in *plant community* result and change the nutritional value (*forage quality*) and amount of forage (*forage production* or equivalently forage quantity) produced. Forage quality affects individual animal weight gain (*cattle performance*). Forage production also affects the *stocking rate*, and together these control the *cattle production* (in pounds per acre) of a meadow. We explain these steps in detail and present the data and assumptions for each step below.

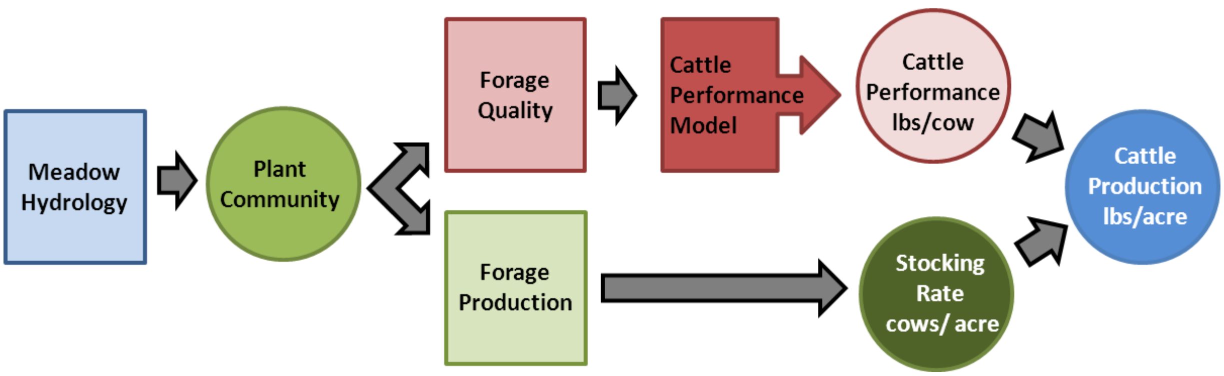
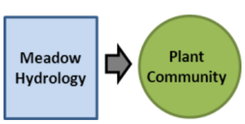


Figure 2. This conceptual model shows how changes in meadow hydrology are expected to affect cattle production. For example, when the water table is raised through restoration (or through irrigation), this change in *hydrology* leads to a *plant community* suited to moister soils. The moist plant community is both more nutritious (*forage quality*) and more productive (*forage production*) than the dry plant community. A computer *cattle performance model* is used to predict the increase in weight-gain per cow (*cattle performance*), from the improved forage quality. In addition, the increase in forage produced leads to an increase in the potential *stocking rate.* The total increased *cattle production* is predicted in pounds of weight gained per acre.

Step 1: From Meadow Hydrology to Plant Community

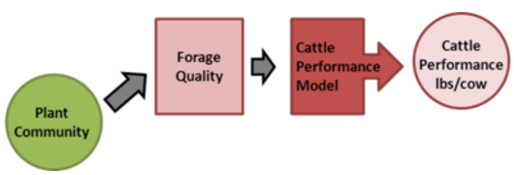


The primary attribute of meadow hydrology that determines the plant community present is the depth of the water table[11–13]. Using values from the literature (see Appendix 2), we classified plant communities as wet, moist, or dry, based on the depth of the water table during the growing season (Table 1).

	Depth to Water Table	Example plant species
Wet	0-10 inches	Beaked Sedge, Narrow-leafed Sedge, Nebraska Sedge, Spikerush
Moist	10-36 inches	Nebraska Sedge, Kentucky Bluegrass, Tufted Hairgrass, Shorthair Sedge
Dry	> 36 inches	Sagebrush, Kentucky Bluegrass with forbs, Annual Grasses.

Table 1. Classification of plant communities into three moisture regimes: wet, moist, and dry, showing representative species. See Appendix 1 for a more detailed, referenced list.

Forage Quality Steps: From Plant Community to Cattle Performance



We estimated forage qualities associated with wet, moist and dry meadow plant communities from unpublished research in Lassen, Plumas, Sierra and Fresno Counties (Table 2). We then used the Oklahoma State University Cow-Culator software to predict average daily weight gains for stockers (calves less than 1 year old, but weaned from their mothers) on wet, moist, and dry meadow vegetation.

Forage quality was best in meadows with moist plant communities and resulted in a season-long gain per head of 232 lbs (Table 3). Meadows with wet plant communities produced somewhat poorer forage and resulted in weight gains 7% lower than moist meadows (216 lbs per head). Dry meadow forage was much poorer in quality forage than either wet or moist meadow forage types, resulting in a gain of 176 pounds per head.

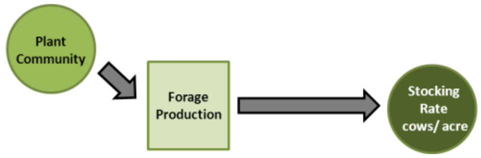
Community	Forage Quality	Early	Mid	Late
Wet	Protein (%)	12-18	9-13	7-11
	ADF (%)	26-32	30-35	35-40
	P (%)	0.17-0.27	0.12-0.20	0.08-0.16
Moist	Protein (%)	12-22	11-16	8-13
	ADF (%)	22-30	30-35	35-40
	P (%)	0.20-0.35	0.12-0.22	0.10-0.20
Dry	Protein (%)	10-15	7-10	4-7
	ADF (%)	28-35	35-40	40-45
	P (%)	0.15-0.25	0.10-0.15	0.05-0.10

Table 2. Estimates for early (June-July), mid (July-August), and late (August-September) growing season forage quality conditions for wet, moist, and dry meadow plant communities. Protein is crude protein, ADF is acid detergent fiber and is an indicator of digestibility (increased ADF indicates reduced digestibility), and P is phosphorus, which is commonly deficient in cattle diets in the Sierra Nevada. All values are reported as a percentage of dry matter intake.

Community	weight gain	Early	Mid	Late	Season-Long
Wet	lb/day	1.84	1.68	1.27	
	total/hd	83	76	57	216 ($259)
Moist	lb/day	1.86	1.71	1.58	
	total/hd	84	77	71	232 ($278)
Dry	lb/day	1.74	1.27	0.92	
	total/hd	78	57	41	176 ($211)

Table 3. Stocker weight gain estimates for early (June-July), mid (July-August), and late (August-September) growing season on wet, moist, and dry meadow plant communities. We estimated weight gain as average daily gain per head (lb/day) during each season, the season total weight gain per head (total/hd over a 45-day season) and the season-long gain and monetary value of this gain (assuming $1.20 per pound) for an individual stocker.

Forage Production Steps: From Plant Community to Change in Stocking Rate



Moist meadow communities also produce the most forage, measured as pounds of dried weight per acre (Figure 3). Dry meadow communities produce 80% less forage than moist meadow communities and 73% less forage than the wet meadow communities (see Table 1 for the species present in each community).

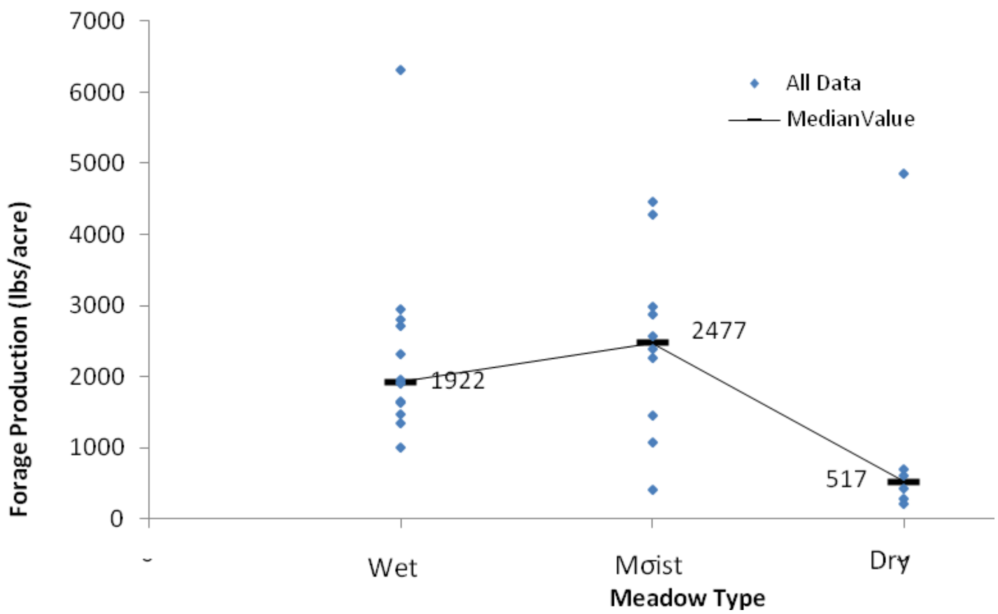


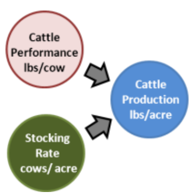
Figure 3. Productivity values for wet, moist and dry community types, measured as pounds dry weight produced annually per acre. Median values are shown. Dry meadow productivity (517 lbs/acre) is 80% less than moist meadow productivity (2477 lbs/acre), and 73% less than wet meadow production. Wet meadow productivity is 22% less than moist meadow productivity. Data and references are included in the appendix.

We used the median forage productivity values to calculate the change in stocking rate when a meadow is converted between different vegetation types by raising the water table, either through restoration or irrigation (Table 4). We assumed cattle consume identical weights of each vegetation type. This assumption is supported by the fact that cattle consume a nearly-constant amount of fiber and the proportion of fiber in each vegetation class overlaps (Table 2). We also assumed stocking rates with identical forage use; that is, a constant percentage of the forage produced was consumed. With these assumptions, the percent change in stocking rate equals the percent change in forage production.

	Increased Forage Production = Increased Stocking Rate
Dry ⟶ Moist	379%
Dry ⟶ Wet	272%
Moist ⟶ Wet	-22%

Table 4. The increase in stocking rate that will result in identical forage use (same percentage of forage consumed), when moving from one community type to another. Negative values indicate a decrease in stocking rate.

Total Cattle Production: Combining Forage Quality and Forage Production.



Raising the water table in areas of dry meadow vegetation results in substantially more cattle production (lbs of stocker/ acre) as a result of improved forage quality and higher potential stocking rates. The change in total cattle production resulting from a raised water table is calculated as the product of the change in weight gain and the change in stocking rate for the affected acreage (Table 5).

To estimate the change in pasture value due to a proposed restoration project, the area of pasture in each class in Table 5 is estimated and weighted by the expected change in production. For example, if two acres are converted from dry to moist vegetation and one acre from moist to wet vegetation, two acres would produce 532% more pounds of stocker per acre, and one acre would produce 28% less. The combined 3 acres would produce an average of 345% more pounds of stocker per acre. Clearly, the most important vegetation changes are from a dry plant community to either wet or moist meadow communities. Also important is any area taken out of productivity, to either maintain the restoration, or because an area has becomes too wet to graze. The spreadsheet accompanying this document[14] will do these calculations for you.

	Increased Stocking Density	Increased Weight Gain per head	Total Increased Production (Stocking Density X Weight Gain)
Dry ⟶ Moist	379%	32%	532%
Dry ⟶ Wet	272%	23%	356%
Moist ⟶ Wet	-22%	-7%	-28%

Table 5. The increases in productivity and weight gain expected when converting between vegetation communities.

Conclusions and Next Steps

A degraded or dewatered meadow has real consequences for cattle performance and ranch profits. Restoration activities which return shallow water tables and increase soil moisture will lead to plant communities that increase meadow forage quality and value for livestock production.

There are also ranch enterprise costs and benefits associated with meadow degradation and restoration which cannot be calculated in terms of pounds of gain per acre or per head. Factors such as increased or reduced management flexibility and availability or lack of high quality forage at key times can change the ranch’s overall bottom line. For example, after restoration, the grazing season may be delayed by wetter soil conditions, which may increase or reduce flexibility. We intend to investigate some of these factors.

Other next steps in this project are to apply the cattle production estimates for wet, moist, and dry meadow conditions to several case studies. We also need to improve our estimates of intake by cattle, as it is likely that intake is lower on dry plant communities. This would further widen the performance gap between moist/wet and dry plant communities.

Notes and References

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Appendix

Hydrologic regime	Site Classification (common names)	Site Classification (scientific names)
xeric	Kentucky bluegrass with forbs	Poa pratensis Semi-Natural Herbaceous Stands (1)
	Sagebrush with grass understory	Artemisia tridentata ssp. vaseyana Shrubland Alliance (1, 2)
	Short-hair sedge	Carex filifolia Herbaceous Alliance (1)
dry mesic	Kentucky bluegrass turf	Poa pratensis Semi-Natural Herbaceous Stands (1)
	Small-winged sedge meadows	Carex microptera Provisional Herbaceous Alliance
mesic	Kentucky bluegrass turf	Poa pratensis Semi-Natural Herbaceous Stands (1)
	Nebraska sedge meadows	Carex nebrascensis Herbaceous Alliance (1)
	Shorthair sedge - Shorthair reedgrass Plant Association	Calamagrostis breweri Vegetative Series (3), Shorthair sedge - Shorthair reedgrass Plant Association (4)
	Tufted hair grass meadows	Deschampsia caespitosa Herbaceous Alliance (1)
	White corn lily patches	Veratrum californicum Herbaceous Alliance (1)
wet-mesic	Beaked sedge and blister sedge meadows	Carex (utriculata, vesicaria) Herbaceous Alliance (1)
	Few-flowered Spikerush Vegetation Series; Few flowered spikerush/Primrose monkey flower Plant Association	Eleocharis pauciflora Vegetation Series (3); Eleocharis pauciflora/Mimulus primuloides (4)
	Jones's sedge turf	Carex jonesii Herbaceous Alliance (1)
	Kentucky bluegrass turf	Poa pratensis Semi-Natural Herbaceous Stands (1)
	Narrow leaved sedge/Kentucky bluegrass meadow	Carex angustata/Poa pratensis (5)
	Tufted hair grass meadows	Deschampsia caespitosa Herbaceous Alliance (1)
wet	Beaked sedge and blister sedge meadows	Carex (utriculata, vesicaria) Herbaceous Alliance (1)
	Slender Spikerush Vegetation Series	Eleocharis tenuis vegetation series
	Few-flowered Spikerush Vegetation Series (Ratliff 1985); Few flowered spikerush/Primrose monkey flower Plant Association (Potter 2005)	Eleocharis pauciflora Vegetation Series (3); Eleocharis pauciflora/Mimulus primuloides (4)
	Narrow leaved sedge meadows	Carex angustata (5)
	Nebraska sedge meadows	Carex nebrascensis Herbaceous Alliance (1)
	Pale spikerush marshes	Eleocharis macrostachya Herbaceous Alliance (1)

(1) Sawyer, Keeler-Wolf and Evans 2008
(2) Not exact fit to published vegetation type
(3) Ratliff 1985
(4) Potter 2005
(5) Allen-Diaz 1991

Table A1 Vegetation types associated with the five hydrologic regimes in Sierra meadows

Citation	Vegetation Type Class	Hydrologic regime	Production Total Dry lb/acre (convert to)	Protein (% dry wt)	TDN (% dry wt.)	Ca (% dry wt)	P (% dry wt)	Ca:P ratio (end of season)	Project location
Van Dyke and Darragh 2006	Artemisia tridentata ssp. vaseyana Shrubland Alliance (1)	xeric	432	12.88					South central **Montana**
Kauffman et al. 2004	Poa pratensis Semi-Natural Herbaceous Stands (1)	xeric	4853						Middle Fork John Day River, **Oregon**
Cole et al. 2004	Carex filifolia Herbaceous Alliance (1)	xeric	687						Gaylor Lakes basin (Yosemite/Sierra Nevada)
Cole et al. 2004	Carex filifolia Herbaceous Alliance (1)	xeric	602	525					Gaylor Lakes basin (Yosemite/Sierra Nevada)
Ratliff 1985	Carex filifolia Herbaceous Alliance (1)	xeric	285						Sierra Nevada
Murphy 2009		xeric	200	13				8.75	west and west-central Sierra Valley and Goodrich Creek
Dwire et al. 2004	Poa pratensis Semi-Natural Herbaceous Stands (1)	dry mesic	5834.85						West Chicken Creek in Eastern Oregon
Dwire et al. 2004	Poa pratensis Semi-Natural Herbaceous Stands (1)	dry mesic	4576.88	5206					Limber Jim Creek in Eastern Oregon
McIlroy 2008	Carex microptera Provisional Herbaceous	dry mesic	2315						Sierra National Forest, Stanislaus National Forest
Murphy 2009		mesic	400	13				7.1	west and west-central Sierra Valley and Goodrich Creek
McIlroy 2008	Veratrum californicum Herbaceous Alliance (1)	mesic	4453						Sierra National Forest, Stanislaus National Forest
McIlroy 2008	Veratrum californicum Herbaceous Alliance (1)	mesic	4283	3908					Stanislaus National Forest
McIlroy 2008	Veratrum californicum Herbaceous Alliance (1)	mesic	2987						Stanislaus National Forest
McIlroy 2008	Carex nebrascensis Herbaceous Alliance (1)	mesic	2873						Sierra National Forest, Stanislaus National Forest
Cole et al. 2004	Calamagrostis breweri Vegetative Series(2), Shorthair sedge - Shorthair reedgrass Plant Association (3)	mesic	2391	1635					Tuolumne Meadows
Allen-Diaz 1991	Poa pratensis Semi-Natural Herbaceous Stands (1)	mesic	2264.8						Sagehen Creek Basin, northern Sierra Nevada
Cole et al. 2004	Calamagrostis breweri Vegetative Series (2), Shorthair sedge - Shorthair reedgrass Plant Association (3)	mesic	1450						Tuolumne Meadows
Ratliff 1985	Calamagrostis breweri Vegetative Series (2), Shorthair sedge - Shorthair reedgrass Plant Association (3)	mesic	1065						Sierra Nevada
Allen-Diaz 1991	Deschampsia caespitosa Herbaceous Alliance (1)	mesic	2563						Sagehen Creek Basin, northern Sierra Nevada

Table A2: Vegetation types, with available information on production rates and nutrient content, organized by hydrologic regime.

Citation	Vegetation Type Class	Hydrologic regime	Production Total Dry lb/acre (convert to)	Protein (% dry wt)	TDN (% dry wt.)	Ca (% dry wt)	P (% dry wt)	Ca:P ratio (end of season)	Project location
Cole et al. 2004	Deschampsia caespitosa Herbaceous Alliance (1)	wet-mesic	3323						Harden Lake
Cole et al. 2004	Deschampsia caespitosa Herbaceous Alliance (1)	wet-mesic	3248						Harden Lake
Ratliff 1985	Deschampsia caespitosa Herbaceous Alliance (1)	wet-mesic	2405	2992					Sierra Nevada
McIlroy 2008	Carex (utriculata, vesicaria) Herbaceous Alliance (1)	wet-mesic	3293	3288					Stanislaus National Forest
McIlroy 2008	Carex (utriculata, vesicaria) Herbaceous Alliance (1)	wet-mesic	3283						Stanislaus National Forest
Allen-Diaz 1991	Poa pratensis Semi-Natural Herbaceous Stands (1)	wet-mesic	3085.16						Sagehen Creek Basin, northern Sierra Nevada
Allen-Diaz 1991	Carex angustata/Poa pratensis (4)	wet-mesic	2750.91						Sagehen Creek Basin, northern Sierra Nevada
McIlroy 2008	Carex jonesii Herbaceous Alliance (1)	wet-mesic	2177						Sierra National Forest, Stanislaus National Forest
McIlroy 2008		wet-mesic	2004						Sierra National Forest, Stanislaus National Forest
Ratcliff 1985	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet-mesic	1145						Sierra Nevada
McIlroy 2008	Eleocharis macrostachya Herbaceous Alliance (1)	wet	2712						Sierra National Forest
McIlroy 2008	Eleocharis macrostachya Herbaceous Alliance (1)	wet	2314						Sierra National Forest
Kauffman et al. 2004	Carex nebrascensis Herbaceous Alliance	wet	6317						Middle Fork John Day River, Oregon
Allen-Diaz 1991	Carex angustata (4)	wet	2953.41						Sagehen Creek Basin, northern Sierra Nevada
Ratliff 1985	Carex nebrascensis Herbaceous Alliance (1)	wet	2805						Sierra Nevada
Murphy 2009		wet	1950	12.75				6.9	west and west-central Sierra Valley and Goodrich Creek
McIlroy 2008	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet	1922						Sierra National Forest
McIlroy 2008	Eleocharis macrostachya Herbaceous Alliance (1)	wet	1893						Sierra National Forest
Ratcliff 1985	Carex (utriculata, vesicaria) Herbaceous Alliance (1)	wet	1650						Sierra Nevada
McIlroy 2008	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet	1625						Sierra National Forest
McIlroy 2008	Few-flowered Spikerush Vegetation Series (2); Few flowered spikerush/Primrose monkey flower Plant Association (3)	wet	1477						Sierra National Forest
Murphy 2009		wet	1350	15				4.5	west and west-central Sierra Valley and Goodrich Creek
Ratliff 1985	Slender Spikerush Vegetation Series (2);	wet	1010						Sierra Nevada

(1) Sawyer Keeler-Wolf and Evans 2008
(2) Ratliff 1985
(3) Potter 2005
(4) Allen-Diaz 1991

Table A2 continued. Vegetation types, with available information on production rates and nutrient content, organized by hydrologic regime.